HEWLETT-PACKARD CALCULATOR

Model 9100A

Operating and Programming

HEWLETT hp PACKARD

WARRANTY AND ASSISTANCE

The Hewlett-Packard 9100A Calculator is warranted against defects in material and workmanship. This warranty applies for one year from the date of delivery for calculators returned to the nearest HP field office. We will repair or replace parts which prove to be defective during the warranty period. No other warranty is expressed or implied. We are not liable for consequential damages.

For any assistance contact your nearest Hewlett-Packard Sales and Service Office. Addresses are provided on pages 32 and 33 of this manual.

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OPERATING AND PROGRAMMING

HEWLETT PACKARD 9100A

GENERAL DESCRIPTION

This section contains general information about the Model 9100A. Included is a discussion of calculator performance checks, accessories supplied with the Model 9100A, and information concerning servicing.

The Hewlett-Packard 9100A Calculator is a scientific desktop calculator. Trigonometric and logarithmic functions are calculated with a single keystroke. The Model 9100A is programmable; conditional branch instructions provide complete programming capability. In addition, two programs can be recorded on each magnetic card supplied with the 9100A.

The Calculator has two memory systems. One is a unique Hewlett-Packard Read-Only-Memory. It contains the subroutines necessary to execute the keyboard instructions and to calculate the trigonometric and logarithmic functions.

The 9100A also contains a magnetic core memory which adds the storage and programming features. There are 19 accessible registers in the magnetic core memory: three are displayed, two are only for data storage and 14 can be used for program storage or for additional data storage. The 14 program registers can accommodate up to 196 program steps.

Three registers are displayed on the cathode ray tube; they are designated x KEYBOARD, y ACCUMULATOR and z TEMPORARY. The format of the display can be selected on the keyboard. With Floating Point notation, the contents of the registers are displayed as a ten-digit number and a two-digit exponent, indicating the power of ten multiplier. This mode of display allows simultaneous presentation of very large (up to 10^{99}) and very small (down to 10^{-98}) numbers. With Fixed Point notation, the contents of the registers are displayed in decimal format, with the number of digits to the right of the decimal (0 to 9) set by the decimal thumbwheel. Regardless of the display mode selected, the 9100A operates in Floating Point calculating all answers to 12 digits, of which ten are displayed.

INITIAL INSPECTION

The calculator was carefully inspected both mechanically and electrically before shipment. It should be physically free of mars or scratches and in perfect electrical order upon receipt. To confirm this, the calculator should be inspected for physical damage in transit. Also check for supplied accessories listed in Table 1 (page6), and test the electrical performance of the calculator.

A magnetic program card loaded with the Diagnostic Program (See page 28, for an explanation) is in the pocket on the rear cover of the Program library. To enter the program:

SET: ON
SET: RUN
SET: RADIANS
SET: FIXED

PRESS: GO TO ( ) ( ) 0 0

Be sure magnetic card is fully inserted in the card reader with the printed side of the card toward the keyboard.

PRESS: ENTER

PRESS: CONTINUE

Execution of the program (indicated by a flashing display of X=3., Y=2.000000 and Z = 1.) ensures that the 9100A is operating correctly.

If the calculator is damaged or an electrical deficiency is indicated, file a claim with the carrier or refer to the warranty on the inside front cover of this manual.

CAUTION
USE A SOFT CLOTH TO CLEAN THE DISPLAY BEZEL. AN ABRASIVE MATERIAL WILL SCRATCH THE SURFACE.

POWER REQUIREMENTS

The Model 9100A requires either 115 or 230 volts ac ±10%, 50 to 60 Hertz and 400 Hertz and requires less than 70 watts of power. With the calculator disconnected from the ac power source, slide the line voltage switch on the rear panel until the line voltage to be used appears.

CAUTION
DO NOT APPLY OPERATING POWER TO THE 9100A CALCULATOR UNLESS THE LINE VOLTAGE SWITCH ON THE REAR PANEL IS IN THE PROPER POSITION. OTHERWISE, DAMAGE TO POWER TRANSFORMER MAY RESULT.

GROUNDING REQUIREMENTS

To protect operating personnel, the National Electrical Manufacturers' Association (NEMA) recommends that the calculator keyboard and cabinet be grounded. The calculator is equipped with a three-conductor power cable which, when plugged into an appropriate receptacle, grounds the cabinet of the calculator. The round pin on the power cable three-prong connector is the ground connection.

ACCESSORIES EQUIPMENT SUPPLIED

The accessories and equipment supplied with each Model 9100A are listed in Table 1.

TABLE 1
Accessories/Equipment Supplied

PART NO.	QUANTITY	DESCRIPTION
09100-90001	2	Operating and Programming Manual
09100-90002	1	Program Library
09100-90003	1	Program Pad
09100-90004	1	Magnetic Program Card Loaded with Diagnostic Program
4040 - 0350	1	Dust Cover
5060 - 5919	1	Magnetic Program Card Container with Ten Program Cards
8120 - 0078	1	Power Cord
9320 - 1157	1	Pull-out Instruction Card contained in the bottom of the 9100A

A box of five program pads (Part No. 09100-90000) is available.

SERVICE CONTRACTS

Service contracts are available for the 9100A Calculator. For further information contact your local Hewlett-Packard Sales and Service office. (See pages 32 and 33 for office locations.)

OFF ON

Switches ac line power to the Calculator. Application of ac line power lights the register designators at the right of the cathode ray tube.

DEGREES RADIANS

Selects the entry and display units for the trigonometric functions.

PROGRAM RUN

Selects the mode of operation.

RUN: used to perform calculations, address the program counter and execute a program.

PROGRAM: used to enter a program from the keyboard and verify a program.

FLOATING FIXED

Selects the mode of display.

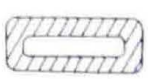
FLOATING DECIMAL POINT: the display consists of a ten-digit number and a two-digit exponent, indicating the power of ten multiplier.

NUMBER	DISPLAY
$12{,}345.67898 = 1.234567898 \times 10^4$	1.234 567 898 04

FIXED DECIMAL POINT: the number is displayed with the decimal point correctly located. The decimal wheel sets the number of places to the right of the decimal point. The least significant digit is rounded. If the number overflows to the left of the decimal point, the display for the overflowed register reverts to floating decimal point.

DECIMAL WHEEL SETTING	DISPLAY
	12345.67898
	_12345.679 ↑ Leading Zeros Blanked ↑ Last Digit Rounded
	Number too large for this setting - automatically shifts to floating decimal point.

The error light indicates an illegal operation such as division by 0., $\sqrt{-x}$, $\sin^{-1}x$ ($|x|>1$), $\ln x$ ($x<0$). An illegal operation during program execution will not stop the program.



NUMBER ENTRY

Clears the X, Y, Z, *e* and *f* registers (0. ⟶ X,Y,Z,*e* and *f*). Clears the FLAG and clears the ARC and HYPER conditions.

Clears the X register (0. ⟶ X). Clears the ARC and HYPER conditions. It is not necessary to press CLEAR *x* before each entry.

Changes the sign of the contents of the X register. Changes the sign of the exponent if ENTER EXP was pressed.

Sets the decimal point. It is not necessary to enter the decimal point when entering integers or when using the ENTER EXP key.

Clears the exponent and causes the next digit entries (0 to 99) and CHG SIGN to affect only the exponent. The exponent digits are entered in a serial manner, with each new digit entry becoming the least significant digit of the exponent.

Pressing ENTER EXP after any keyboard operation, except digit entry, will enter 1.0 for the number in X.

ALL KEYBOARD ENTRIES ARE DISPLAYED IN THE X REGISTER.

SET: FLOAT

ENTER: 126.78

or

SET: FLOAT

ENTER: $-39{,}800 = -3.98 \times 10^4$

CLEAR x | CHG SIGN | 3 | 9 | 8 | 0 | 0 | or

CLEAR x | 3 | 9 | 8 | CHG SIGN | ENTER EXP | 4

SET: FIXED

SET: Decimal wheel to **4**

ENTER: .0094

CLEAR x | 9 | 4 | ENTER EXP | 3 | CHG SIGN | or

CLEAR x | . | 0 | 0 | 9 | 4

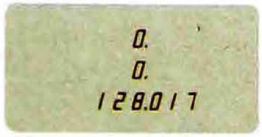
SET: FIXED

SET: Decimal wheel to **4**

ENTER: 128.0167

CLEAR x | 1 | 2 | 8 | . | 0 | 1 | 6 | 7

SET: Decimal wheel to **3**



SET: Decimal wheel to **8**

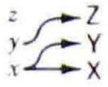
SET: FLOAT

ENTER: -4×10^{-12}

CLEAR x | CHG SIGN | 4 | ENTER EXP | CHG SIGN | 1 | 2

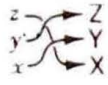
CONTROL KEYS

The Control Keys reposition the contents of the displayed registers as required for succeeding calculations. x, y and z refer to the contents of X, Y and Z.

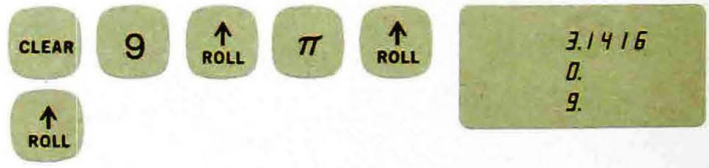


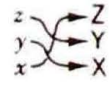
Duplicates the contents of X to the Y register and shifts the contents of Y to the Z register. Loses the contents of the Z register.

Duplicates the contents of Z to the Y register and shifts the contents of the Y register to the X register. Loses the contents of the X register.

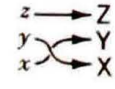


Shifts the contents of X to the Y register, shifts the contents of Y to the Z register and shifts the contents of Z to the X register.





Shifts the contents of Z to the Y register, shifts the contents of Y to the X register and shifts the contents of X to the Z register.



Exchanges the contents of the X and Y registers. The contents of Z are unchanged.

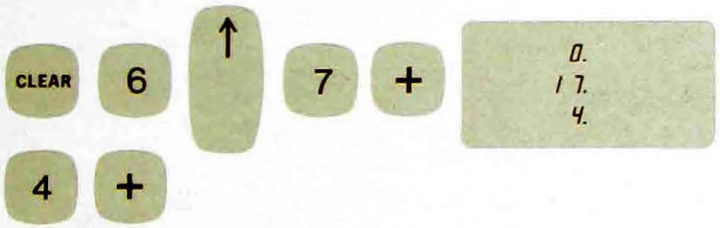
ARITHMETIC KEYS

The arithmetic keys operate on the X and Y registers, entering the result of the calculation into the Y register and leaving the X register unchanged.

Adds the contents of the X register to the contents of the Y register. The sum is entered into the Y register and the X register is unchanged.

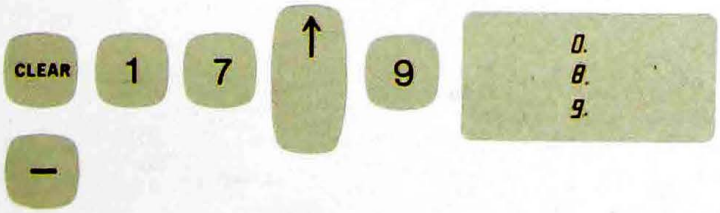
$8 + 4 = 12 \rightarrow Y$

$6 + 7 + 4 = 17 \rightarrow Y$

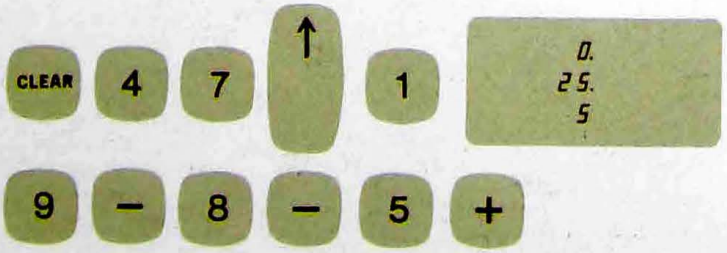


Subtracts the contents of the X register from the contents of the Y register. The difference is entered into the Y register and the X register is unchanged.

$17 - 9 = 8 \rightarrow Y$



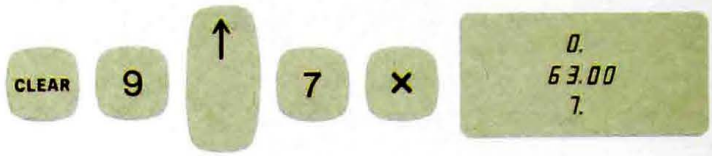
$47 - 19 - 8 + 5 = 25 \rightarrow Y$



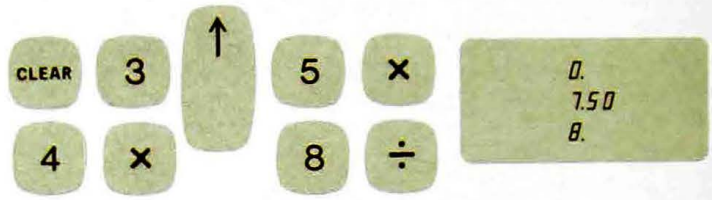
ARITHMETIC KEYS

Multiplies the contents of the Y register by the contents of the X register. The product is entered into the Y register and the X register is unchanged.

$9 \times 7 = 63 \rightarrow Y$



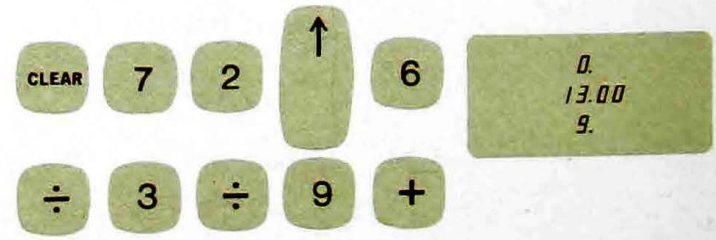
$3 \times 5 \times 4 \div 8 = 7.5 \rightarrow Y$



Divides the contents of the Y register by the contents of the X register. The quotient is entered into the Y register and the X register is unchanged.

$36 \div 4 = 9 \rightarrow Y$

$72 \div 6 \div 3 + 9 = 13 \rightarrow Y$



EXAMPLE $\dfrac{(3 \times 4) + (6 - 9)}{(8 \times 2) - 6} = .9 \rightarrow Y$

STEP	KEY
1—	3
2—	↑
3—	4
4—	×
5—	6
6—	+

STEP	KEY
7—	9
8—	−
9—	8
10—	↑
11—	2
12—	×

STEP	KEY
13—	6
14—	−
15—	↓
16—	÷

The Storage and Recall Keys provide access to the 16 storage registers: 0, 1, 2, 3, 4, 5, 6, 7, 8, 9, *a*, *b*, *c*, *d*, *e* and *f*. It is not necessary to clear a register before storing a number; write over the previously stored number.

Stores the contents of X in the register indicated by the following keystroke: 0, 1, 2, 3, 4, 5, 6, 7, 8, 9, *a*, *b*, *c*, *d*, *e* or *f*. The contents of the X register are unchanged.

Stores the contents of Y in the register indicated by the following keystroke: 0, 1, 2, 3, 4, 5, 6, 7, 8, 9, *a*, *b*, *c*, *d*, *e* or *f*. The contents of the Y register are unchanged.

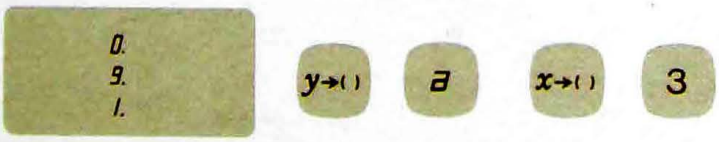
CONTROL-RECALL

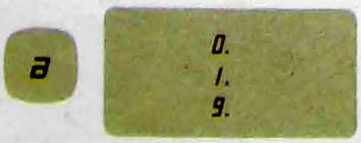
Press *a*, *b*, *c*, *d*, *e* or *f* to recall the contents of that register to the X register. The contents of *a*, *b*, *c*, *d*, *e* or *f* are unchanged. The $y \rightleftarrows ( )$ key must be used to recall the contents of the numeric registers. Pressing only 0, 1, 2, 3, 4, 5, 6, 7, 8, 9 will not recall the contents of that register to the X register, but will enter that digit in the X register.

Recalls the contents of *f* and *e* to the X and Y registers. The contents of *f* and *e* are unchanged.

CONTROL-STORAGE AND RECALL

Exchanges the contents of Y with the contents of the register indicated by the following keystroke: 0, 1, 2, 3, 4, 5, 6, 7, 8, 9, *a*, *b*, *c*, *d*, *e* or *f*. This is the only instruction that recalls the contents of a numeric storage register.





FUNCTION KEYS

DEGREES RADIANS

Selects the entry and display units for the trigonometric functions. To convert from **DEGREES (RADIANS)** to **RADIANS (DEGREES)**:

1) SET: **DEGREES (RADIANS)**
2) ENTER: **DEGREES (RADIANS)**
3) PRESS: **sin x**, **cos x**, **tan x**
4) SET: **RADIANS (DEGREES)**
5) PRESS: **arc** ▼ **sin x**, **cos x**, or **tan x**; answer in **RADIANS (DEGREES)** is entered into the X register.

Inverse trigonometric functions are calculated for the principal value of the function.

$\theta = \sin^{-1} x$; $-90° \leq \theta \leq +90°$; $(-\pi/2 \leq \theta \leq +\pi/2)$

$\theta = \cos^{-1} x$; $0° \leq \theta \leq +180°$; $(0 \leq \theta \leq \pi)$

$\theta = \tan^{-1} x$; $-90° \leq \theta \leq +90°$; $(-\pi/2 \leq \theta \leq +\pi/2)$

EXAMPLE

$\sin +135° = +.7071$; $\sin^{-1} +.7071 = +45.°$

sin x

Replaces the contents of the X register with the Sine of the contents of X.

cos x

Replaces the contents of the X register with the Cosine of the contents of X.

tan x

Replaces the contents of the X register with the Tangent of the contents of X.

arc ▼

Prefix used to calculate the inverse trigonometric and hyperbolic functions. The answer is entered into the X register.

hyper ▼

Prefix used to calculate the hyperbolic (sinh, cosh, and tanh) functions. The answer is entered into the X register.

EXAMPLE: $\sinh^{-1} 2 = 1.4436$

CORRECT

2 arc ▼ hyper ▼ sin x

$\sinh^{-1} 2 \rightarrow X$

INCORRECT

2 hyper ▼ arc ▼ sin x

$\sin^{-1} 2 \rightarrow$ **ERROR LIGHT**

Replaces the contents of the X register with the square root of the contents of X.

Replaces the contents of the X register with the logarithm to the base e of the contents of X.

Replaces the contents of the X register with e raised to the power defined by the contents of X.

Replaces the contents of the X register with the logarithm to the base 10 of the contents of X.

Integer x. Eliminates the decimal part of the contents of the X register. Enters the integer into the X register.

Absolute value of y. Sets the contents of the Y register positive.

Enters pi into the X register.

VECTOR KEYS

Conversion from rectangular to polar coordinates will calculate the angle, θ, in the range:

$$-180° < \theta \leq +180°$$

$$-\pi \text{ radians} < \theta \leq +\pi \text{ radians}$$

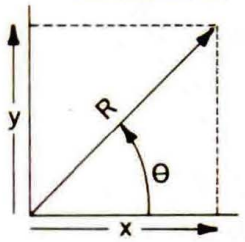
TO POLAR

Changes rectangular coordinates consisting of an x component in the X register and a y component in the Y register to polar coordinates:

$$\text{Angle } (\theta) = \text{Tan}^{-1}\ y/x \longrightarrow Y$$

$$\text{Radius } (R) = \sqrt{x^2 + y^2} \longrightarrow X$$

SET: **DEGREES**



CLEAR 4 CHG SIGN ↑ 3 TO POLAR

0.
-53.1301
5.

TO RECT

Changes polar coordinates consisting of a radius (R) in the X register at an angle (θ) in the Y register to rectangular coordinates:

$$\text{y component} = R \times \text{Sin } \theta \longrightarrow Y$$

$$\text{x component} = R \times \text{Cos } \theta \longrightarrow X$$

CLEAR 2 2 5 ↑ 2 $\sqrt{x}$ TO RECT

0.
-1.0000
-1.0000

ACCUMULATE +: Adds the contents of the X and Y registers to the contents of the *f* and *e* registers respectively. The sums are entered into the *f* and *e* registers. *f* and *e* are cleared with the CLEAR instruction.

$f + X \longrightarrow f$

$e + Y \longrightarrow e$

ACCUMULATE −: Subtracts the contents of the X and Y registers from the contents of the *f* and *e* registers respectively. The differences are entered into the *f* and *e* registers.

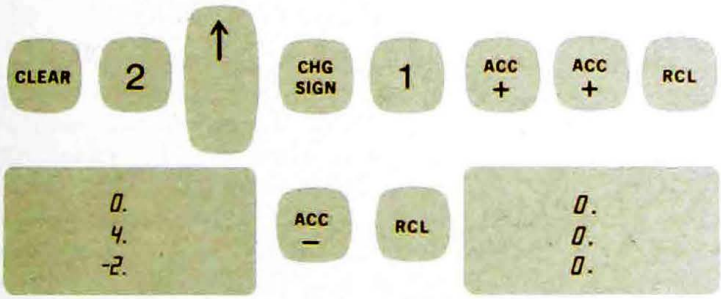
$f - X \longrightarrow f$

$e - Y \longrightarrow e$

Recalls the contents of the *f* and *e* registers to the X and Y registers respectively. The contents of *f* and *e* are unchanged.

$f \longrightarrow X$

$e \longrightarrow Y$



EXAMPLE: Vector Addition

$(2x + 3y) + (4x + 5y) - (3x - 6y) = 3x + 14y$

STEP	KEY	STEP	KEY	STEP	KEY
1—	CLEAR	6—	5	11—	CHG SIGN
2—	3	7—	↑	12—	↑
3—	↑	8—	4	13—	3
4—	2	9—	ACC +	14—	ACC −
5—	ACC +	10—	6	15—	RCL

EXAMPLE: Multiplication of complex numbers ($j^2 = -1$)

$(3 + j4)(-2 + j3) = -18 + j1$

STEP	KEY	STEP	KEY	STEP	KEY
1—	CLEAR	7—	ACC +	13—	ln *x*
2—	4	8—	3	14—	ACC +
3—	↑	9—	↑	15—	RCL
4—	3	10—	2	16—	e^x
5—	TO POLAR	11—	CHG SIGN	17—	TO RECT
6—	ln *x*	12—	TO POLAR		

PROGRAMMING

The Hewlett-Packard Model 9100A has a maximum capacity of 196 program steps. The 0, 1, 2, 3, 4, 5, 6, 7, 8, 9, *a*, *b*, *c*, and *d* registers can be used for either program or data storage. The X, Y and Z registers are the display registers and the *e* and *f* registers are only data storage registers; these five registers cannot be used for program storage.

Program storage consists of a 14 by 14 array (see Figure 1). The registers are designated 0, 1, 2, 3, 4, 5, 6, 7, 8, 9, *a*, *b*, *c*, and *d* as are the characters in each register. Memory address *c*2 indicates the *c* register and character 2 in the *c* register.

A program is stored so that the register with the starting address of the program is filled with the program steps before the next sequential register is entered to store program steps. With the first program step in location 00, program storage will be used in the following manner: 00, 01, . . . 09, 0*a*, 0*b*, 0*c*, 0*d*, 10, . . . 19, 1*a*, 1*b*, 1*c*, 1*d*, 20 . . . up to *dc*, *dd*, the address at which the program counter resets to 00.

It is not necessary to learn a program language for the Calculator. Keyboard operations are the program instructions. Each program step is one keyboard instruction.

Programs that require more storage than the *e* and *f* registers necessitate use of a register that could be used for program storage. A complete register is required for storing a ten-digit number and the two-digit exponent; therefore, the maximum program size of 196 steps is reduced by 14 steps for each program register used for data storage.

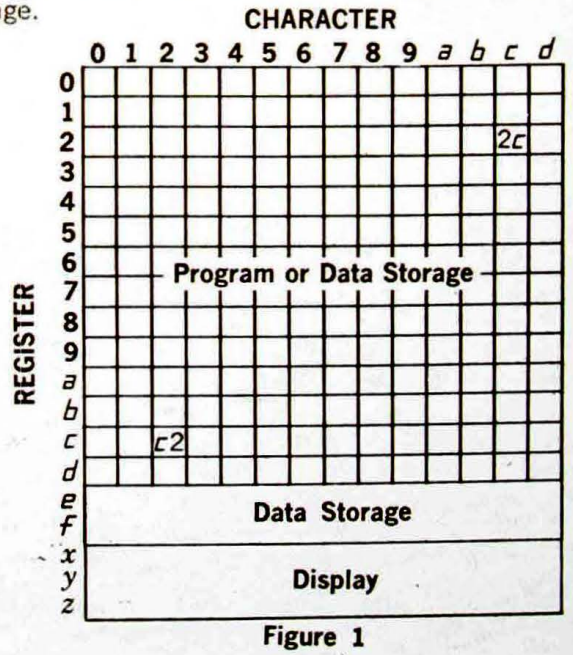


Figure 1

Selects the mode of operation.
RUN: used to perform calculations, address the program counter and execute a program.
PROGRAM: used to enter a program from the keyboard and verify a program.

Causes an unconditional branch to the program address entered by the next two keystrokes or by the next two program steps. Each program step can be only one keystroke.

CORRECT

STEP	KEY
29	GO TO ( ) ( )
2a	5
2b	C

INCORRECT

STEP	KEY
29	GO TO ( ) ( )
2a	5 C
2b	

Starts program execution at the present address. If the program has halted execution at a STOP instruction, pressing CONTINUE will start program execution with the next program step. If the program has halted execution at an END instruction, pressing CONTINUE will start program execution at program step 00. CONTINUE can also be used as a 'no operation' program step. See the program for N!, page 26.

Halts program execution and causes a return to the display mode. The STOP instruction provides an unconditional halt of program execution for entry of data or display of results. Pressing CONTINUE begins program execution with the next program step. Pressing STOP during execution of a program will cause the program to stop execution at the present program step and will cause a return to the display mode. Pressing CONTINUE will begin program execution with the next program step.

Use the STOP instruction to enter data. With the program at a STOP or END instruction any keyboard operation can be manually executed, provided that no data is stored in a register containing program steps. Storing data in a register containing program steps will destroy the program steps in that register.

Halts program execution and causes a return to the display mode. The instruction resets the program counter to 00 so that pressing CONTINUE begins program execution at step 00.
END must be the last instruction in a program. Reading the END instruction from the magnetic card stops the reading process and resets the program counter to 00.

PROGRAMMING

PROBLEM: Write a program to solve $\frac{A \times B}{A + B}$ for any A and B.

STEP	KEY	x	y	z	f	e	
00	CLEAR	0	0	0	0	0	Clear display & e & f.
01	STOP	A	B				Stop to enter A & B.
02	x→( )						
03	e					A	
04	y→( )						Store A and B.
05	f	A	B	0	B		
06	×		AxB				
07	↑		A	AxB			Move AxB to Z to calculate A + B.
08	f	B					
09	+		A+B				
0a	ROLL ↓	A+B	AxB	B			Position AxB and A+B to calculate quotient.
0b	÷		$\frac{AxB}{A+B}$				
0c	ROLL ↑	B	A+B	$\frac{AxB}{A+B}$			
0d	x⇄y		B				
10	e	A					
11	END	A	B	$\frac{AxB}{A+B}$			Final Display

See ENTERING A PROGRAM-FROM THE KEYBOARD (Page 24). A blank register indicates the contents of the register are unchanged from the previous step.

PAUSE

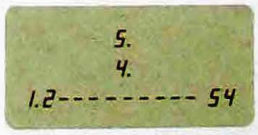
Causes a brief display before continuing with execution of the program. If the PAUSE key is held depressed during execution of a program, a STOP will occur at the next PAUSE instruction in the program. Pressing CONTINUE will begin execution with the next program step. Use successive PAUSE instructions for a longer display.

STEP PRGM

This instruction single-steps the program. The display will depend upon the mode of operation: PROGRAM or RUN. This is the only instruction that cannot be a program step.

PROGRAM: Single-steps the program, displaying in X the program step address and the code of the instruction in that program step.

EXAMPLE:



Program step 12 contains the SET FLAG instruction; its code is 54.

RUN: Single-steps execution of the program displaying the contents of the X, Y, and Z registers after each step. Enter data at the proper program step to check operation of the program.

Each STEP PRGM keystroke executes the three steps of a GO TO ( ) ( ) and executes the conditional branch instructions in the following manner:

CONDITION MET

Conditional branch with an address in the next two program steps.

Executes the conditional branch and branches to the given address.

Conditional branch with instructions in the next two program steps.

Executes the conditional branch and the next instruction.

CONDITION NOT MET

Branches to and executes the third step following the conditional branch instruction.

NOTE

To verify a program with RUN selected, replace each CONTINUE instruction with either a PAUSE or STOP instruction. If a CONTINUE instruction is encountered, the Calculator will begin execution of the program.

Print the contents of X, Y or Z or any combination as selected on the printer. If no printer is being used, the PRINT instruction will act as the STOP instruction.

The FORMAT instruction controls the accessory output devices. If no accessory output device is being used, the FORMAT instruction will act as the STOP instruction. For complete information, see the Operating and Service Manual for the particular accessory.

IF $x<y$

IF $x=y$

IF $x>y$

These instructions cause a conditional branch to one of two program locations dependent upon the contents of the X and Y registers. If the condition tested is met, the program will either branch to the address stored in the next two program steps or, if no address is given, execute the instructions in the next two program steps, and continue with the third program step following the conditional branch instruction. If the condition tested is not met, the program branches to and executes the third program step following the conditional branch instruction.

If the contents of X=6. and the contents of Y =5., the condition (IF X > Y) is met. The program will branch to step 08, the address given in steps 03 and 04, and enter 1. in the X and Y registers. If the contents of X=−5. and the contents of Y=−2., the condition is not met. The program will branch to step 05 and enter 2. in the X and Y registers.

STEP	KEY
00	CLEAR
01	STOP
02	IF $x>y$
03	0
04	8
05	2

STEP	KEY
06	↑
07	STOP
08	1
09	↑
0a	END

If the contents of X and Y are equal, the condition (If X=Y) is met. The program will execute steps 03 and 04 and continue with step 05, calculate $x^2 + y^2$ (See TO POLAR, page 16) and enter the answer into X. If the contents of X and Y are not equal the program will branch to step 05, calculate the product of X x Y and enter it into X.

STEP	KEY
00	CLEAR
01	STOP
02	IF $x=y$
03	TO POLAR

STEP	KEY
04	↑
05	×
06	↓
07	END

IF FLAG

This instruction causes a conditional branch to one of two program steps depending upon whether or not the FLAG was set either manually or by a program step with the SET FLAG instruction. The condition is met if the FLAG was set. Branching after the IF FLAG instruction is the same as for the conditional branch instructions given above. The instruction also clears the FLAG.

SET FLAG

Set the FLAG condition which is tested by the conditional branch instruction IF FLAG. This instruction and the IF FLAG instruction allow the operator to control program execution by either manual entry or program step entry of the SET FLAG instruction.

PROBLEM: Calculate the average value ($\overline{X}$) of N data points, x_i. Use the SET FLAG to indicate entry of the last data point.

SOLUTION

STEP	KEY
00	CLEAR
01	1
02	↑
03	STOP
04	IF FLAG
05	0
06	*b*
07	ACC +
08	GO TO ( ) ( )
09	0
0*a*	1
0*b*	RCL
0*c*	$x \rightleftarrows y$
0*d*	÷
10	END

ENTER PROGRAM
PRESS: **GO TO (0) (0) (or END)**
PRESS: **CONTINUE**
ENTER DATA: $x_i \longrightarrow X$
PRESS: **CONTINUE**
After Last Data Entry,
PRESS: **SET FLAG**
PRESS: **CONTINUE**
Display:

$\overline{X} \longrightarrow Y$
$n \longrightarrow X$

NOTE

The only sequence of instructions after a conditional branch instruction which will not give the expected results is a numeric or alphabetic instruction followed by a non-arithmetic or non-alphabetic instruction. The program will branch to the address (J) (K) given by the numeric or alphabetic instruction (J) and the second digit (K) of the address of the third instruction following the conditional branch instruction. The program will also execute the instruction in the second program step following the conditional branch instruction.

EXAMPLE:

STEP	KEY
04	IF $x<y$
05	2
06	ROLL ↓
07	÷

If the contents of X = 3. and the contents of Y = 5., the condition (IF X < Y) is met; the program will continue to step 05. The ROLL ↓ instruction will be executed and the program will then branch to step 27 (determined by the 2 in step 05 and the second digit of the address in step 07) rather than entering 2 in the X register and performing the ROLL ↓ .

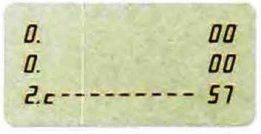
ENTERING A PROGRAM

FROM THE KEYBOARD

1. SET: [RUN]
2. PRESS*: [GO TO] [Starting Address]
3. SET: [PROG]
4. Press keys in program sequence.
5. SET: [RUN]
6. PRESS*: [GO TO] [Starting Address]

   The program will execute the instruction in the starting address when CONTINUE is pressed.
7. Enter data and press CONTINUE as necessary for program execution.

When entering a program, the address for the instruction entered and the code of that instruction are displayed in the X register.



Step 2c contains the instruction.

FROM A MAGNETIC CARD

1. SET: [RUN]
2. PRESS*: [GO TO] [Starting Address]
3. Insert card, press: [ENTER]
4. PRESS*: [GO TO] [Starting Address]
5. Enter data and press CONTINUE as necessary for program execution.

NOTE

When entering or recording a program:

1) Hold the ENTER or RECORD key pressed until the card is partially ejected from the card reader.
2) The contents of Y and Z are unchanged.
3) ENTER: contents of X unchanged.
   RECORD: contents of X destroyed.

[PAUSE]

See "CORRECTING A PROGRAM STEP" (Page 25) if an incorrect instruction is entered in the program.

*** NOTE**

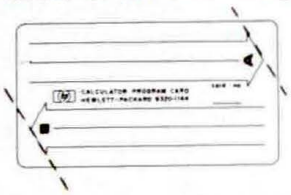
Any address can be used for the first program step. However, a beginning address of 0-0 is generally used because of the convenience provided by the END instruction. Core storage is usually used beginning at the top (location 0-0) for program storage and beginning at the bottom (register f) for data storage.

RECORDING A PROGRAM

Two programs can be recorded on each magnetic card. The programs are designated A and B. To read or record program A, insert the card with the A arrow pointing down and the printed side of the card toward the keyboard. To read or record program B, insert the card in the same manner with the B arrow pointing down.

1. SET: [RUN]
2. PRESS: [GO TO] [Starting Address]
3. INSERT CARD, PRESS: [RECORD]

To permanently save a program recorded as program A or B, cut off the corner of the card along the tip of the A or B arrow.



VERIFYING A PROGRAM

After a program is entered in storage it can be verified by selecting either the PROGRAM or RUN mode of operation.

PROGRAM

1. SET: [ ] [RUN]
2. PRESS: [GO TO] [Starting Address]
3. SET: [PROG] [ ]
4. Each STEP PRGM keystroke will increment the program counter. The X register will display the program step address and the code of the instruction in that location.

```
0.          00
0.          00
8.9 - - - - - - - 70
```

Step 89 contains the sin x instruction.

RUN

1. SET: [ ] [RUN]
2. PRESS: [GO TO] [Starting Address]
3. Each STEP PRGM keystroke will single-step the program, displaying the contents of the X, Y, and Z registers. Enter data at the correct program step to check operation and solution of the program. While editing, replace every CONTINUE instruction with a PAUSE or STOP instruction. Encountering a CONTINUE instruction while editing in the RUN mode of operation will cause the Calculator to begin automatic execution of the program.

The key codes are given on page 3 and on the pull-out instruction card.

CORRECTING A PROGRAM STEP

1. SET: [ ] [RUN]
2. PRESS: [GO TO] [Step to be changed]
3. SET: [PROG] [ ]
4. ENTER CORRECT INSTRUCTION.
5. a. TO CONTINUE EDITING:
   PRESS: [STEP PRGM]
   b. TO EXECUTE PROGRAM:
   SET: [ ] [RUN]
   PRESS: [GO TO] [Starting Address]

CALCULATE N FACTORIAL (N!)

STEP	KEY	x	y	z	f	e
00	CLEAR	0	0	0	0	0
1	STOP	N	ENTER N → X			
2	x→( )					
3	f				N	
4	IF x=y					
5	CONTINUE					
6	1	1				
7	↑	N	N			
8	↑	N	N	N		
9	1	1				
a	−	1	N′−1	N′		
b	IF x>y					
c	1					
d	6					
10	ROLL ↓	N′−1	N′	1		
1	×		N′(N′−1)			
2	ROLL ↑	1	N′−1	N′(N′−1)		
3	GO TO ( ) ( )					
4	0					
5	a					
6	0	0	N′−1	N!		
7	ROLL ↓	N′−1	N!	0		
8	f	N	N!	0		
9	END	N	N!	0	- DISPLAY -	

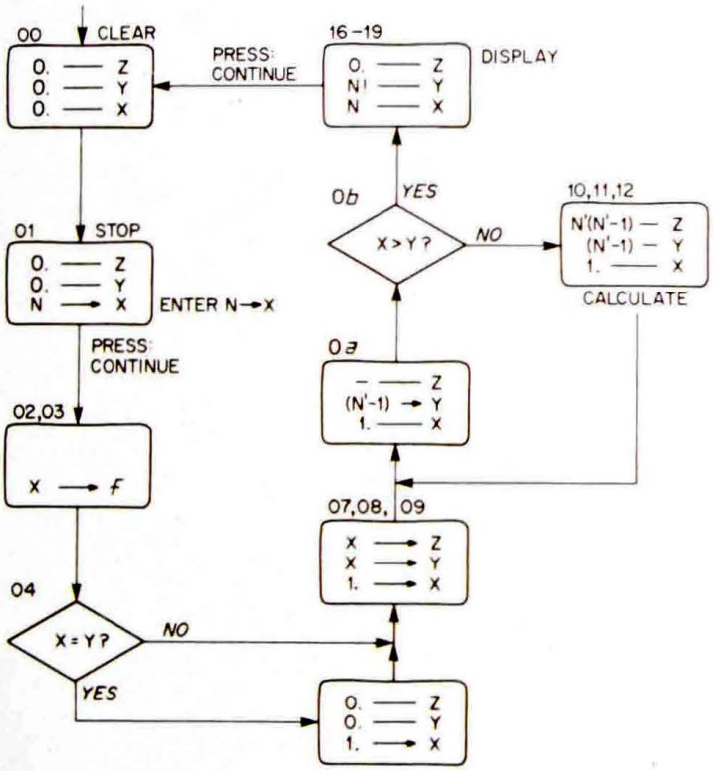
A blank register indicates the contents of the register are unchanged from the previous step.

CALCULATE N FACTORIAL (N!)

$N! = N\,(N-1)\,(N-2)\ldots(N-N+2)\,(1)$

$6! = (6)\,(5)\,(4)\,(3)\,(2)\,(1) = 720$

$0! = 1$



The IF X=Y is met at step 04 if N = 0; set 0! = 1. N′ is the partial product calculation. Each IF X > Y at step 0*b* not met develops next partial product. After 1st pass, N′ = N (N−1). After 2nd pass, N′ = N (N−1) (N−2)

DIAGNOSTIC PROGRAM

The Diagnostic Program exercises every subroutine in the Calculator by program step entry of instructions rather than keyboard entry. Proper operation of the Calculator and the Diagnostic Program is indicated by a flashing display: X = 3., Y = 2.0000, Z = 1.
Symptoms of improper operation are no display or a fixed display, indicating that program execution has stopped. To determine the program step at which the program stopped,

SET: PROG

PRESS: STEP PRGM

The program step displayed in X is the step following the program step at which the STOP occured. Single-step the program from the last error check (previous STOP instruction in the program) to the program step where the error was detected. If all instructions are correct, single-step the entire program.

No data entry is necessary for program operation. To run the program:

SET: ON

SET: RUN

SET: RADIANS

SET: FIXED

PRESS: GO TO ( ) ( ) 0 0

The Diagnostic Program is listed in the Program Library under Miscellaneous.

INSERT CARD IN THE CARD READER WITH THE PRINTED SIDE TOWARD THE KEYBOARD.

PRESS: ENTER

PRESS: CONTINUE

ENTERING A CONSTANT

During program execution a constant can be entered in the X register by program step entry rather than using a complete register to store the constant and recalling it when needed.

STEP	KEY
22	ROLL ↑
23	2
24	.
25	1
26	3
27	×

After program step 26 is executed, 2.13 will be in the X register.

$\sqrt{\text{SUM OF THE SQUARES}}$

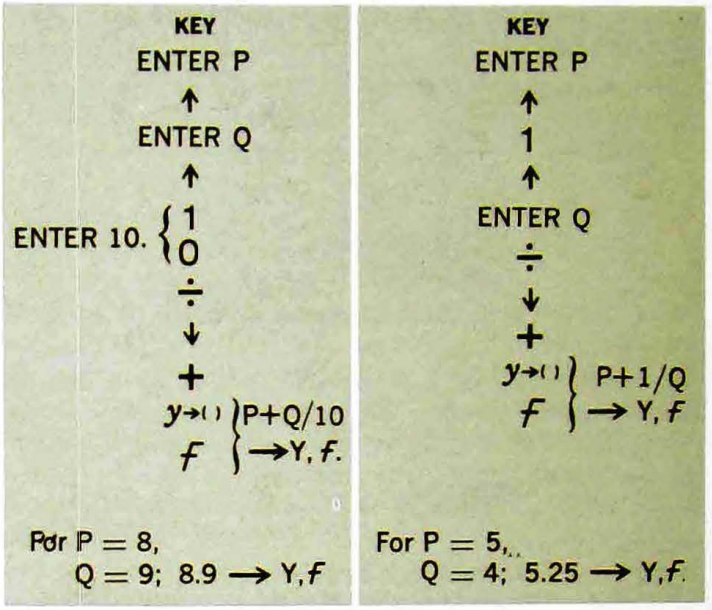
PROBLEM: Calculate $\sqrt{P^2 + Q^2}$

KEY
ENTER P
↑
×
ENTER Q
↑
×
↓
+
↓
$\sqrt{x}$
$\sqrt{P^2 + Q^2} \rightarrow X$

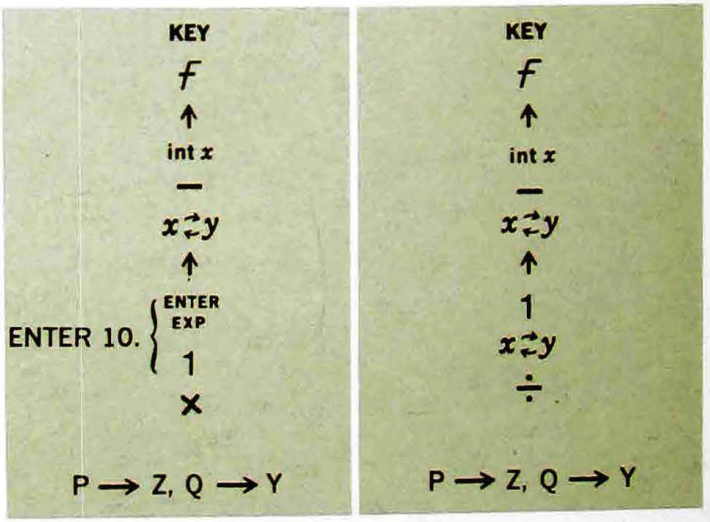
KEY
ENTER P
↑
ENTER Q
TO POLAR
$\sqrt{P^2 + Q^2} \rightarrow X$

SPLITTING A REGISTER

PROBLEM: Save a storage register by storing two integers, P and Q, in one register.



To Obtain P and Q



USE OF THE FLAG

PROBLEM: Calculate $\Sigma (-1)^n f_n (X)$

First Term Positive **First Term Negative**

FLAG NOT SET ON FIRST PASS

STEP	KEY
00	
01	Calculate $f_n (X)_n$ in X or Y.
⋮	
42	IF FLAG
43	4
44	8
45	SET FLAG
46	ACC +
47	ACC +
48	ACC −

STEP	KEY
00	
01	Calculate $f_n (X)_n$ in X or Y.
⋮	
42	IF FLAG
43	4
44	8
45	SET FLAG
46	ACC −
47	ACC −
48	ACC +

NUMBER ENTRY

Pressing ENTER EXP causes the following CHG SIGN and digit entries to be entered as the exponent of X. After ENTER EXP is pressed, pressing the decimal point key will return the control of the CHG SIGN and digit keys to the number in X.

3 ENTER EXP CHG SIGN 4 •

```
0.        00
0.        00
3.        -04
```

CHG SIGN 9 8

```
0.        00
0.        00
-3.98     -04
```

Any number with an absolute value of less than 1×10^{-9} must be entered using the ENTER EXP key. It cannot be entered in decimal format.

For example, 1×10^{-10}:

• 0 0 0 0 0 0 0 0 1

```
0.        00
0.        00
1.        -00
```

ADDITIONAL PROGRAM STORAGE

The *e* and *f* registers can be used for program steps. However, each must be addressed with a GO TO (*e*) (0) or a GO TO (*f*) (0) to enter program steps. *e*0 is displayed as −.0 and *f*0 is displayed as 1.0. The step following *ed* is *a*0 and following *fd* is *c*0. Branching to any other address requires direct branching with the GO TO ( ) ( ) and address instructions as the last three steps in either *e* or *f*. Program steps in the *e* and *f* registers cannot be recorded on the magnetic card.

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